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A Computer-Based Instructional Support Network: Design, Development, and Evaluation

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Design, Development, and Evaluation

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13. ABSTRACT *(Maximum 200 words)*

The objective of the work was to design, develop, and evaluate an experimental, computer-based Instructional Support Network (ISN) consisting of an electronic communication network linking students to instructional resources such as instructors and instructional materials. A key element of the ISN concept was to provide very simple, easy to use workstations for instructor and students, enabling effective system use with minimal training and technical support. Without outside support, users were successfully able to set up and operate prototype workstations in less than two hours. During a field test, the ISN was used to link continuing education calculus students with a tutor at the Naval Postgraduate School. The majority of ISN messages during this test were administrative (72.9%), 17.3 percent were technical, and 9.8 percent were motivational. Students initiated 40.9 percent of messages, and the tutor initiated the remainder. Some evidence shows that use of the ISN reduced student attrition and helped students with weak mathematics background.

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FOREWORD

This technical report describes work conducted as part of the Navy Personnel Research and Development Center's Communication Networks in Training (CNIT) project in the general area of remote-site training. The CNIT project is one part of the Schoolhouse Training product line and falls under the Personnel and Training Technology (NP2A) Block of the 6.2 Mission Support Technology Program Element 0602233N (Work Unit No. RM33T23.02). The work was performed under the sponsorship of the Office of Naval Technology.

The objective of the project is to find more cost-effective ways to train personnel who are geographically remote from training resources. The project has been exploring the use of new communication technologies to export training to geographically-remote students. Among these technologies are computer networking, two-way video, facsimile, and other media.

This technical report describes work carried out during the initial phases of the project. It is intended to document work performed and provide a sketch of the computer-based prototype instructional support network evaluated during FY89.

The authors gratefully acknowledge the help of the Naval Postgraduate School (NPS) in the conduct of the research reported in this document. We are particularly indebted to Dr. Robert Zucker, director of Continuing Education through spring of 1989; Mr. Theodore Calhoon, Dr. Zucker's successor; Drs. Maurice Weir and William Little of the Mathematics Department; Mr. Douglas Williams and Ms. Carolyn Miller of the NPS computer center; and the continuing education students who participated in the study.

Some software used in the Instructional Support Network was developed under contract N6601-88-D-0054 by Systems Engineering Associates (SEA), Inc.

The recommendations in this technical report are intended for use by the Chief of Naval Operations (OP-11) and the Chief of Naval Education and Training in developing policy for the application of advanced communication technology in Navy training.

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v

SUMMARY

Background and Problem

A requirement exists to train Navy personnel who are geographically remote from training resources. This requirement exists due to the dispersal of home ports, training facilities, fleet units, and Naval Reserve detachments. Evolving technologies have the potential to reduce the impact of geography on training. For example, computer networking can link together student and instructor across great distances and across time. The solution to the Navy's remote-site training problem lies in the proper selection and use of new communication technologies.

Objective

The overall objective of the project is to explore more cost-effective ways to train personnel who are geographically remote from training resources. The objective of the work described in this technical report was to develop, test, and evaluate an experimental, computer-based Instructional Support Network (ISN). The ISN consists of an electronic communication network linking students to instructional resources such as instructors and instructional materials.

Approach

A preliminary ISN concept was developed and then refined and focused in a series of steps. These steps included a survey of related projects and research and development efforts, selection of a research testbed, design and development of a prototype ISN, and conduct of a field test.

Findings

Formative Evaluation

Subjects were successfully able to unpack their ISN system, set it up, get it running, receive a message, print out a message, compose a message, and send a message within less than two hours.

Process Measures

Student Message Traffic. The majority of ISN messages (72.9%) were administrative, 17.3% were technical, and 9.8% were motivational. Students initiated 40.9% of messages, and the tutor initiated the remainder.

ISN Support Requirements. ISN support personnel included a full-time tutor, part-time software engineer, occasional "hot-line" support, and occasional support from the NPS host computer. The technical support by the software engineer averaged one to two hours per week; hot-line support, about 30 minutes per week; and computer center support, about 30 minutes per week.

The tutor estimated that he could have tutored as many as 40 students with the ISN, and perhaps more.

Tutor Comments. The tutor characterized the ISN as a "great" tutoring tool that both students and tutor found easy to learn to use. ISN problems identified by the tutor included slow student

progress with lessons, lack of communication by students, NPS host computer problems that precluded student-tutor communication, DDN problems that precluded student-tutor communication, and inability (by tutor) to diagnose cause of student noncommunication. Suggestions for improving the ISN included providing students with a syllabus containing a suggested schedule for progress through their course, working with students' work supervisors to allow them to "ease off" on their duties to provide more time for their studies, and providing additional capabilities within the ISN software.

Technical Problems. The ISN is a complex arrangement of computers, software, and long-distance networks whose operability depends on all components working properly; the failure of any single component usually compromises the entire system. While the ISN was in use, nearly every component in it failed at least once. Most failures were minor and were quickly corrected, but a few affected the ISN for several weeks and required software modifications. ISN software and hardware were reliable and robust; the most serious problems were the result of system elements beyond the immediate control of ISN support personnel, e.g., NPS host hardware or software downtime, or MILNET downtime.

Formal Evaluation

Some evidence shows that use of the ISN reduced student attrition and was particularly helpful to students with weak mathematics backgrounds; this conclusion was not supported by tests of statistical significance, however.

Students who used the ISN rated their tutor's knowledge of mathematics and tutoring skill more highly than students undergoing conventional instruction.

Conclusions

The use of electronic mail appears to have limited application for instructional delivery in the Navy. However, an electronic mail system with the simplicity and user friendliness of the ISN would be a major improvement over existing electronic mail systems and would be useful for sharing information among training professionals and other Navy personnel.

Recommendations

1. The use of electronic mail should not be considered as a primary instructional delivery medium by the Navy.

2 The Chief of Naval Education and Training should give serious consideration to developing a Navy-wide, DDN-based, electronic-mail network for sharing information ("knowledge networking") among training professionals and other Navy personnel. The design of this network could be modeled on the ISN.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Problem and Background

A requirement exists to train Navy personnel who are geographically remote from training resources. This requirement exists throughout the Navy, but is perhaps most obvious for personnel aboard ships at sea. Shipboard training is limited by available training resources and the skills of shipboard trainers. By necessity, personnel are periodically assigned to formal schools to receive training they cannot receive aboard ship. Strategic homeporting may disperse Navy ships over a greater number of smaller, more geographically isolated ports. As training resources and personnel tend to concentrate near larger ports, strategic homeporting can be expected to accentuate the training problem. Even without the homeporting issue, the locations of existing training facilities often require fleet personnel to travel away from their home duty station to complete required training. The remote-site training requirement also exists in the Naval Reserves. Reservists typically belong to small detachments, widely dispersed geographically, with limited training resources, few qualified trainers, and little time to train. The requirement to overcome geographic distance in training delivery is a generic problem that exists in the civilian public education and industrial world as well as in the military world.

Evolving technologies have the potential to reduce the impact of geography on training. For example, computer networking can link students and instructors across great distances. Asynchronous communication with electronic mail permits communication across time. Programs with artificial intelligence can be used to support training, reducing the need for live instructors and the load on existing instructors. These technologies are becoming increasingly available and have the potential to reduce the Navy's remote site training problems.

The solution to the Navy's remote-site training problem lies in the proper selection and use of new communication technologies. In general, these technologies are costly and constantly changing; new technologies appear regularly. Proponents of one technology or another proclaim the virtues of their favorite. Many technologies are being used on a regular basis; others, in demonstration projects. Investigators are exploring strengths and limitations, cost effectiveness, and other dimensions governing suitability for different applications. Unfortunately, there is no road map to follow to determine which technology is "best" in a particular application today and which will be "best" next week, next year, or ten years from now. The Communication Networks in Training (CNIT) project is exploring different technologies, research and development projects, and the Navy's training problems in order to gain a better understanding of which technologies hold the greatest potential for future use in the Navy.

Objective

The primary objective of the CNIT project is to find more cost-effective technological approaches to train personnel who are geographically remote from training resources. This objective is being addressed along four different tracks:

1. Assess the applicability of new communication technologies to the solution of Navy training problems caused by geographic dispersal of training.

2. Develop, test, and evaluate an experimental computer-based instructional support network.

3. Develop, test, and evaluate an experimental, two-way videoteletraining system

4. Investigate the impact of alternative equipment configurations and training delivery methods on training effectiveness in a videoteletraining laboratory.

This technical report describes the work performed on track 2 during FY88 and FY89. The track 2 work concerned the design, development, and evaluation of a simple, computer-based instructional support network intended for use by personnel with little or no computer experience. Other project documentation describes work performed during the same periods on tracks 1 and 3 (see Simpson, 1990; Simpson, Pugh, & Parchman, in press). The work performed on track 4 is commencing during FY90 and will be reported in the future.

APPROACH

Overview

The project began with the development of a preliminary Instructional Support Network (ISN) concept. This concept was then evaluated, refined, and focused in a series of steps. These steps included a survey of related projects and research and development efforts, selection of a research testbed, design and development of a prototype ISN, and conduct of a field test.

Preliminary ISN Concept

The preliminary ISN concept was a very simple, relatively inexpensive, user-friendly system to link students to an instructor across geographic distance and time. The concept was based on electronic mail, but was to incorporate features not normally found in mail systems and to be much easier to use than traditional mail systems.

The preliminary ISN concept consisted of three elements:

1. A communication network linking the student to instructional resources (e.g., instructor, training materials, question and answer database).

2. Simple, easy to use workstations for student and instructor.

3. Operating procedures, documentation and technical/logistical support.

The first element of the ISN concept was predicated on the use of computers and computer networking. (The ISN concept can be extended to use video or other media, but that was not the intention of this project.) The ISN would be built to work within the Defense Data Network (DDN), which is already in place and widely used for data transfer and electronic mail. The DDN is described in greater detail in the appendix.

The second element of the ISN concept, while straightforward, is unusual in terms of traditional electronic mail systems. Most of these systems are intended for use by personnel with considerable computer sophistication and who have ready access to technical support. The ISN concept called

2

for a much simpler system that would be easy to master and use, and requires minimal external support.

The third element of the ISN concept is the procedures, documentation, and support system needed to make ISN work.

The preliminary ISN concept did not define the instructional setting, although, again, it was implicit that, owing to its networking features and ability to bridge distance, the ISN would have its greatest payoff for remote-site instructional applications, where student and instructional resources were far apart. There was nothing to preclude its use in the confines of a classroom, but this did not appear to capitalize on its greatest asset. Because of the intended simplicity of the ISN, it would also have applications outside of instruction. It could be used, for example, to enable knowledge networking among individuals who were physically separated but who wished to share information. Unlike most electronic mail systems, the ISN would be relatively easy to learn and use.

Survey Related Projects

A literature review was conducted using the Manpower and Training Research Information System (MATRIS) and computer data bases for ERIC, the National Technical Information System (NTIS), and PsychInfo. Key topics and subtopics were computer networking (networks in training/instruction, computer conferencing, new networking technologies), and distance education/training. Current information was obtained on some subtopics from articles published electronically and in magazines.

To avoid duplication with other projects, we made a strong effort to identify projects using technology similar to the ISN. Contact was made with researchers in the Navy, Army, and Air Force training communities to discuss research agendas and projects. Through this process, several projects were identified and investigated.

Computer networking is defined, for purposes of this discussion, as the linking together of separate computer nodes (e.g., terminals, workstations) such that text files may be transferred among them under user control, stored locally, and accessed at will. Most networks do not transfer video, sound, or communication modalities other than text but this constraint is eroding rapidly with the advent of plug-in cards that enable computers to transfer facsimiles and still- or slow-frame video using fairly narrow bandwidth telephone lines, e.g., 64 kbps (kilobits per second).

Networks enable their users to communicate across both geographic distance and time. Users do not have to be at the same location or working in the same time frame; a message dropped into an electronic mailbox will be read where received when its recipient reads the computer mail. Networking links computers via local, regional, national, or worldwide networks, which give their users access to he human and computer-based resources of the network.

Computer networks are a relatively recent phenomenon. They began in the early 1970s but have grown steadily so that presently they are accessible on most university campuses, government laboratories, and private firms involved in high technology and/or government contracting. Their primary use is for communication and information sharing and their primary users are technical professionals and managers.

3

Among the most prominent researchers of user interactions with networks are Hiltz, Turoff, and Kerr. Hiltz began her work in the early 1970s with several studies of the Electronic Information Exchange System (EIES), alone and in collaboration with the other two authors (Hiltz & Turoff, 1978; Turoff & Hiltz, 1978; Kerr & Hiltz, 1982). This early work is today recognized as seminal in the field. Hiltz and colleagues found several factors to be predictive of success in the introduction of a network to a new user community (Hiltz, Kerr, & Johnson, 1985). The factors, in order of priority, are:

1. Users must want system at outset.

2. A "critical mass" of users must be interested in communicating with their peers.

3. Strong, active leadership (e.g, management support) must be present.

4. The system must have adequate features, a good user interface, and high reliability.

5. Users must be adequately trained.

6. Technical support must be readily available.

Hiltz et al. found that perceived pressure to use the system was somewhat negatively correlated to use of the network. Perhaps the most surprising finding was that typing ability was not predictive of system use.

Most research into the use of networks has involved sophisticated users; i.e., mature, well-educated individuals with high verbal and reading skills who were self-motivated to use the system and who initiated communications without outside coercion. This is, in essence, the community of the scientific researcher and is a somewhat unique social group. Because of these unique properties, questions have been raised about the applicability of the technology to other social groupings in, for example, the classroom. One of the central questions is how will other user groups (e.g., younger, less well educated, limited reading/verbal skills, external locus of control) interact with networks? Another question is how can a network be used to deliver training? The second question raises several other questions. For example, how does the interaction protocol affect learning variables? How should the system be designed to make it most effective (e.g., type of workstation, user interface, modes of interaction, etc.)? Research is just now beginning to explore some of these questions systematically.

To date, networks have seen limited use in education and training, although their use is growing. Relatively few studies deal with the application of networking technology to instruction. Those that do are generally informal reports of case studies or loosely controlled studies whose generalizability is limited. For example, Barnes, Swehosky, and Laguna-Castillo (1988) report on a classroom experiment involving the use of a local area network (LAN) to support a statistics course; students expressed a liking for the new method of instruction, but performance was on a par with classroom instruction. Levin and colleagues have experimented with the use of networks in the elementary school classroom. In one study, students in classrooms in the U.S., Mexico, Japan, and Israel were linked by network and participated in group problem-solving tasks (Levin,

1985; Levin, Riel, Miyake, & Cohen, 1986). The authors reported that the instructional environment helped students gain insight into problems more fully than they did in a conventional classroom.

In a related study, analysis of electronic mail traffic in a networked instructional environment found that instructor-student discourse had more "strands" and persisted longer than in the classroom (Quinn, Mehan, Levin, & Black, 1983).

An interesting recent research project in the military setting is the Army Research Institute (ARI) Asynchronous Computer Conferencing project (Richards & Phelps, 1987). Work began in 1986 and is ongoing. Computer conferencing over the Army Forum Network is used to link geographically remote students to an instructor and to each other for discussion in an electronic classroom and with smaller working groups. During the first two years, subject matter was the U.S. Army Engineer Officer Advanced course, the instructor was an honors graduate of the course and an Army Reserve Officer who was hired under contract, and students were Army Reserve Officers (Hagman, 1988). Training materials were developed from those used in the corresponding resident course (Hahn, 1988). Primary instructional delivery was with correspondence-type training materials, supported by computer conferencing for discussion. Students were paced through materials at a group rate. Students were also provided with text-editing software for use in preparing written assignments.

Hahn (1988) reported that students quickly became bored when a single medium of presentation was used and opted for variety in presentations to sustain interest. Project participants have reported their experiences and several "lessons learned" (Richards & Phelps, 1987; Phelps & Richards, 1987; Richards, 1988). Among the problem areas were hardware breakdowns, student difficulties in setting up PC-XT computer equipment, lesson pacing problems, and the need for training both instructors and students in the rules of computer conferencing. The ARI project has solved these and many other practical problems of the electronic classroom and offers useful lessons to educators and trainers working in this area. Two additional significant contributions are the design of a metaphorical user interface for students' computers (Halbert, 1988) and considerable well-documented experience in the training of instructors (Kaplan & Jones, 1988).

Educational networks are widely used in colleges and universities. We did not conduct a survey but are aware of several cases which are probably typical. The U.S. Air Force Academy uses a network to tie together students and faculty. All students have access to terminals (actually Zenith 248 computers[1]). The system provides e-mail and there are plans to use it for delivery of computer-aided instructional programs (Regian, 1988). The U.S. Naval Postgraduate school employs a similar LAN. Use of the network depends upon the academic major and the particular instructor; there is no standard way to use the network in instruction (Buoni, 1988). Some instructors do not use it. Others--particularly in more technical majors--use it to transmit homework assignments and solutions to exercises, and to communicate with individual students. These uses are informal in the sense that they are natural outgrowths of the e-mail system and supplant other means of communication such as dropping notes in mailboxes, providing handouts in class, meeting during offices hours. Informal uses of a LAN do not include delivery of instruction or computer conferencing.

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[1]Identification of specific equipment and software is for documentation only and does not imply endorsement.

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Many colleges and universities--particularly those directed at students who hold full-time jobs--now permit students to take some classes by computer; that is, the class is essentially a computer conference. The Western Behavioral Sciences Institute (WBSI) in La Jolla, CA, has for several years used computer conferencing to link together high-level managers at remote sites to study and discuss strategic planning in a course combining classroom meetings and electronic meetings. These educational applications are more formal than those just discussed and, in fact, involve wide-area networks rather than LANs. However, such applications are w :nin the capability of any institution possessing a LAN even if they are not present policy. While the use of LANs appears to be growing in institutions of higher learning, we have found no evidence that this is happening in primary or secondary schools, technical/trade schools, or within the military schoolhouse training environment.

Within the Navy educational/training community, computer networking--more specifically, electronic mail--has grown steadily but not without problems. Today, the Navy research and development centers can communicate using the DDN, but most of the Navy schools are not linked into the system. The Navy education and training community does not use electronic mail in support of instruction. Although institutions such as the Naval Postgraduate School use electronic mail to some extent, its use is idiosyncratic at best. Traditionally, the primary users of computer networks and electronic mail have been scientists and educators. Electronic mail is beginning to find its way into schools, particularly at the college and graduate level. The common denominators of these applications are mature, motivated use- ·ho take the initiative in using the medium.

Beyond its possible application as an instructional support medium, electronic mail can also be used, as noted earlier, for knowledge networking among professional groups (e.g., educational specialists, aviators, supply officers). Currently, the Navy has no formal policy or plan for using electronic mail in this way. This is in contrast to the Army, which established the Army Forum Network (AFN) in 1983 to "link via computer teleconferencing geographically dispersed, multidisciplinary teams capable of rapidly integrating the flow of critical information to enhance the total Army Mission" (Department of the Army, 1986). As of late 1986, AFN had 1200 world-wide participants in 36 subject areas. Most participants are U.S. Army officers, though use is open to personnel in other services and DoD civilians and contractors. Conferences tend to focus on professional topics of common interest. The network is used for both formal and informal sharing of information, experiences and expertise, and is similar to the bulletin boards, conferences, and newsgroups available on the DDN and commercial computer networks. The network allows professionals with common interests to communicate. Thus, for example, ar artillery officer at Ft. Carson, CO, can pose a question to the forum and be answered by a peer at Ft. Lewis, WA. Stated applications include supplanting of face-to-face meetings; supplementing of other forms of communication; providing assistance in coordinating and directing geographically dispersed organizations; providing a medium for ongoing discussions, distribution of information; creating a greater sense of community; and tailoring the communications process to group characteristics.

The AFN is administered by an office in Washington, DC. Interested parties may obtain an information packet from this office with instructions for the use of the network and the establishment of discussion groups. Currently the Navy has no equivalent of the AFN, although the communication infrastructure for such a conferencing system exists in the DDN, which is used by all the armed services and the Army Forum network.

NPRDC participated briefly in the Training Research discussion group of the AFN. A set of instructions was obtained from Ft. Monroe, VA, the Army provided an account, and a link to the net was established using a 1200-baud telephone link (the highest data rate supported). The communication procedures and protocols are primitive by the standards of today's high-speed networks but the AFN has the essential functionality to enable individuals with common professional interests to network their knowledge and perform group problem solving.

Select ISN Testbed

The ISN concept was applicable in many different instructional environments. Project personnel conducted an informal, small-scale survey of Navy instructional environments that were considered possible candidates for the ISN early in the project. This survey included Navy technical schools, Naval Reserve training, the Navy correspondence course program, college- and graduate-level officer training, and shipboard and pierside training. The results of this survey are described in Simpson (1990). The survey eliminated most of these environments as possible settings for the ISN. Prime candidates from the start were Navy correspondence course program and the continuing education program at the Naval Postgraduate School (NPS). Both supported independent study by students, which seemed suitable for a system such as the ISN. Navy technical schools were rejected after school personnel said that their students were highly regimented and lacked the time and initiative to use computers and that a system such as the ISN threatened to reduce the amount of instructor-student interaction. The survey revealed that naval reservists have very serious training problems, that some type of distance training/education technology could benefit them greatly, but that the ISN was not the suitable technology to solve those problems; a better technology was videoteletraining (see Simpson, 1990; Simpson, Pugh, & Parchman, in press). The same conclusion was reached regarding shipboard and pierside training.

The Navy correspondence course program appeared to be a good candidate for the ISN. The program has a large number of students and courses (approximately 60,000 students in 580 courses) and students engage in independent study. However personnel representing this program saw little need for the ISN as the course completion rate overall is 56 percent and, in courses required for advancement in rating, it approaches 100% (King, 1988).

At the time of the survey, the NPS supported a continuing education program that enabled non-resident students to take certain courses by correspondence. The majority of students were active-duty military officers stationed many miles from the NPS. The most common motivation for taking courses was to improve their academic records and their chances of gaining admission to the NPS or other highly selective schools such as test pilot school. The courses offered were correspondence versions of those taught at the NPS and were technical and difficult; roughly half of the students enrolled in college-level mathematics or physics. To support learning on a remote basis, students were supposed to recruit a local tutor knowledgeable in the particular subject area. The attrition rate in these courses was much higher than for Navy correspondence courses generally. According to the former director of continuing education, of the 4,500 students who signed up for a course each year, only 400 successfully completed the course (Zucker, 1988). Possible reasons for such a high attrition rate might include conflicts with work commitments, lack of adequate tutoring, or lack of the peer support available in the normal classroom learning situation. The ISN seemed to have the potential to overcome the tutoring limitation by linking the students to an expert tutor at

the NPS. It also had the potential to link students to peers and thereby provide a degree of peer support. NPS personnel expressed strong interest in the ISN concept and offered their support and resources for developing it at the NPS.

We selected the continuing education program at the NPS as a testbed for the ISN for several reasons. Key among these were that the ISN seemed to have the potential to reduce the severe attrition problem, school personnel were supportive, and the school had an existing computer network that could be readily tied into for use in the ISN.

ISN DESIGN AND DEVELOPMENT

Overview

The ISN was conceived as a prototype electronic mail (e-mail) system whose purpose was to link geographically-remote NPS continuing-education students with a skilled tutor at the NPS. The ISN would be a vehicle for communication between tutor and students, enabling the student to ask questions and obtain answers, and enabling the tutor to track student progress and provide student guidance and motivation.

Basic Design Considerations

One of the first ISN design issues was that computer equipment and software would be packed in boxes and shipped to students at remote locations, where they would be expected to put everything together and make it work. There was no reason to expect students to have computer skills and it would not be feasible to train students face to face.

Thus, the ISN had to satisfy certain basic design requirements:

1. ISN hardware had to be economical, rugged, and easy to assemble.

2. User documentation had to be simple and foolproof.

3. Users would have to be able to assemble and operate their systems and diagnose simple problems using only the documentation.

4. Users without computer skills would be able to use the ISN successfully.

Design Principles

Project personnel examined several MS-DOS based terminal emulation programs in the hope of finding one that could be used without modification in the ISN. None of the software examined was simple enough to meet the third design requirement (listed above). The terminal programs examined did much more than the ISN needed to do and required considerable user computer knowledge to use successfully.

Consequently, a decision was made to have a contractor develop a turnkey-style program, using the authoring language with the "Procomm" terminal program available from Datastorm Technologies. Project personnel wrote a statement of work describing the design. The statement of work and, in turn in, ISN software design reflect five principles:

1. **Simplicity.** The program has the minimum number of functions necessary to perform its job and only one way to perform each action.

2. **Visibility.** Menus display all possible program options on the screen.

3. **Consistency.** Screens are laid out according to a common template, and information is displayed and options exercised similarly from screen to screen.

4. **Self-documentation.** The program displays all options in menus and provides help screens.

5. **Unbreakability.** No matter what the user does, the program must not crash.

These design principles were adopted to provide a starting point and to facilitate communication with the contractor. The principles are idealistic and, when they were adopted, it was not clear how well they could actually be satisfied. Project personnel worked closely with the contractor during software design and development. They tested software, had representative users attempt to use the system, and made numerous suggestions for changes.

Hardware Selection

The Army Research Institute had fielded a system similar to the ISN during the Asynchronous Computer Conferencing project and recommended the use of IBM PC XT compatible Zenith-184 laptop computers and ALPS printers which were more rugged and easier to set up than standard desktop computers (Hagman, 1988). The Z-184 with carrying case weighs less than 10 pounds and includes an 80- by 24-character LCD display, 640 kbytes of RAM, full keyboard, 20 Mbyte hard disk, 3.5-inch floppy disk, and built-in 1200-baud Hayes-compatible modem and printer ports. The compact ALPS printer can be connected to it with a single cable, and a phone jack can be plugged into the modem port in the side of the computer. The telephone line is connected to the computer using an RJ-11 telephone jack. The hardware, at GSA prices, costs less than $1500 per system. The Z-184 and ALPS printer were selected for use by students for the ISN evaluation.

System Overview

Figure 1 provides an overview of the ISN system. The system consists of three basic elements: (1) the DDN communications network, (2) the user's laptop computer, and (3) the IBM mainframe (host) computer at the NPS. The Department of Defense developed the DDN to provide high-speed communications among computers throughout the United States and overseas. The DDN consists of two major networks, the MILNET and the ARPANET. The MILNET handles day-to-day defense data communications and is the part of the DDN used by the ISN system. As shown in Figure 1, a computer at the NPS in Monterey, CA can be connected to computers in other locations.
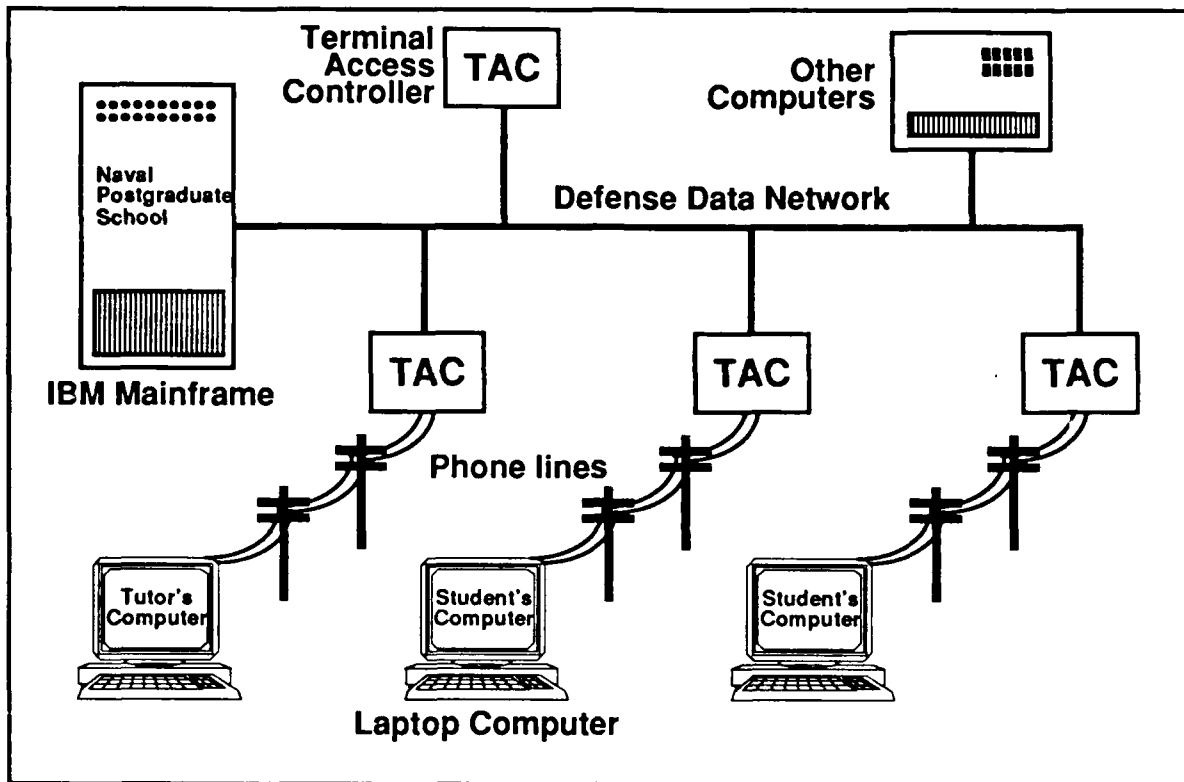
Figure 1. Overview of Instructional Support Network.

Through the DDN, a user at one computer can connect to another computer, log onto it, and work on the second computer. Most computers on the network are connected directly to the DDN. A user also can connect to the DDN through a Terminal Access Controller (TAC). Typically, a modem connects a TAC to a user's computer or terminal through telephone lines. The computer user sends commands to the modem telling it to dial the telephone number for a local TAC. Once a telephone connection is made with the TAC, the user logs onto the TAC, tells the TAC to connect to a specific computer on the network, and logs onto that computer.

The host computer at the NPS is an IBM 3033 running the VM/CMS operating system. The computer is connected directly to the MILNET. The IBM 3033 is a multiuser system that provides basic file handling, data processing, and communications facilities. The VM/CMS operating system also provides an electronic mail facility. The IBM mainframe serves as the hub of the ISN system. All messages sent between students and tutor pass through the host computer and are stored on it until retrieved by their addressee.

Using the ISN is analogous to using a post office box. A letter writer composes a letter at a laptop computer, takes the letter to the post office (the IBM 3033 computer), and puts it in the post office box for the recipient. Later, the recipient goes to the post office, picks up the letter from the post office box, takes it home (to a laptop computer), and reads it.

ISN User's Software

The ISN user's software combines a text editor, terminal program, and simple mail program. Students use the software to compose and transmit messages to their tutor over the DDN, and to receive and store messages from the tutor. The software is set up before being provided to the student. The user must enter his or her password to assure authorization to use the ISN but does not have to dial a phone number, turn on a modem, copy files, use hierarchical directories, or deal with other computer arcana.

The software also provides a data communications handler for se..ding and receiving mail. This handler connects the user's computer to the MILNET and the host computer at the NPS and also handles the transfer of mail files between the computers. The software provides commands for managing the mail files such as deleting and printing messages.

The software combines custom and commercial software packages. The custom software manages the system, controls other software (CSE text editor, Procomm communications software), provides the menu and command line interface, connects each computer to the IBM 3033 at NPS through the MILNET, and automatically transfers message files between the computers. The custom software is a combination of executable programs, batch files, and text files. It includes several configuration programs, which are used to set up or modify each laptop computer for the particular user.

The CSE text editor, which is used to read and edit messages, is a public-domain program developed at the Colorado School of Mines. The editor, though simple, permits the keyboard to be customized. The ISN implementation purposely limits available editing functions to the very minimum such as insert, delete, overwrite.

Procomm is a popular and fairly powerful data communications package developed by Datastorm Technologies, Inc. Procomm handles data communications between different computers, transfers files between machines using a variety of file transfer protocols (Kermit, developed at Columbia University, is used in the ISN implementation), and runs command scripts. Command scripts were used in the ISN to transfer files to and from the IBM computer at NPS.

Figure 2 shows the organization of the ISN program. The seven ISN program operations are capitalized--TRANSMIT, RECEIVE, READ, COMPOSE, DELETE, PRINT, QUIT. All operations except QUIT operate on the Message File.

TRANSMIT and RECEIVE are both "on-line" operations. They require only the Z-184 to be connected to a phone line. TRANSMIT transmits messages from the Message File to the NPS. When selected, TRANSMIT automatically calls the NPS computer on the phone, sends the message to the NPS computer, and hangs up the phone. RECEIVE receives messages from the NPS and stores them in the Message File. RECEIVE is typically used first, after starting the program. When selected, RECEIVE automatically calls the NPS computer on the phone, signs on, collects new messages, puts them in the Message File, signs off, and hangs up the phone.

The remaining operations are performed "off line." READ displays new messages received from the tutor. COMPOSE allows the student to type a message with a very simple text editor and
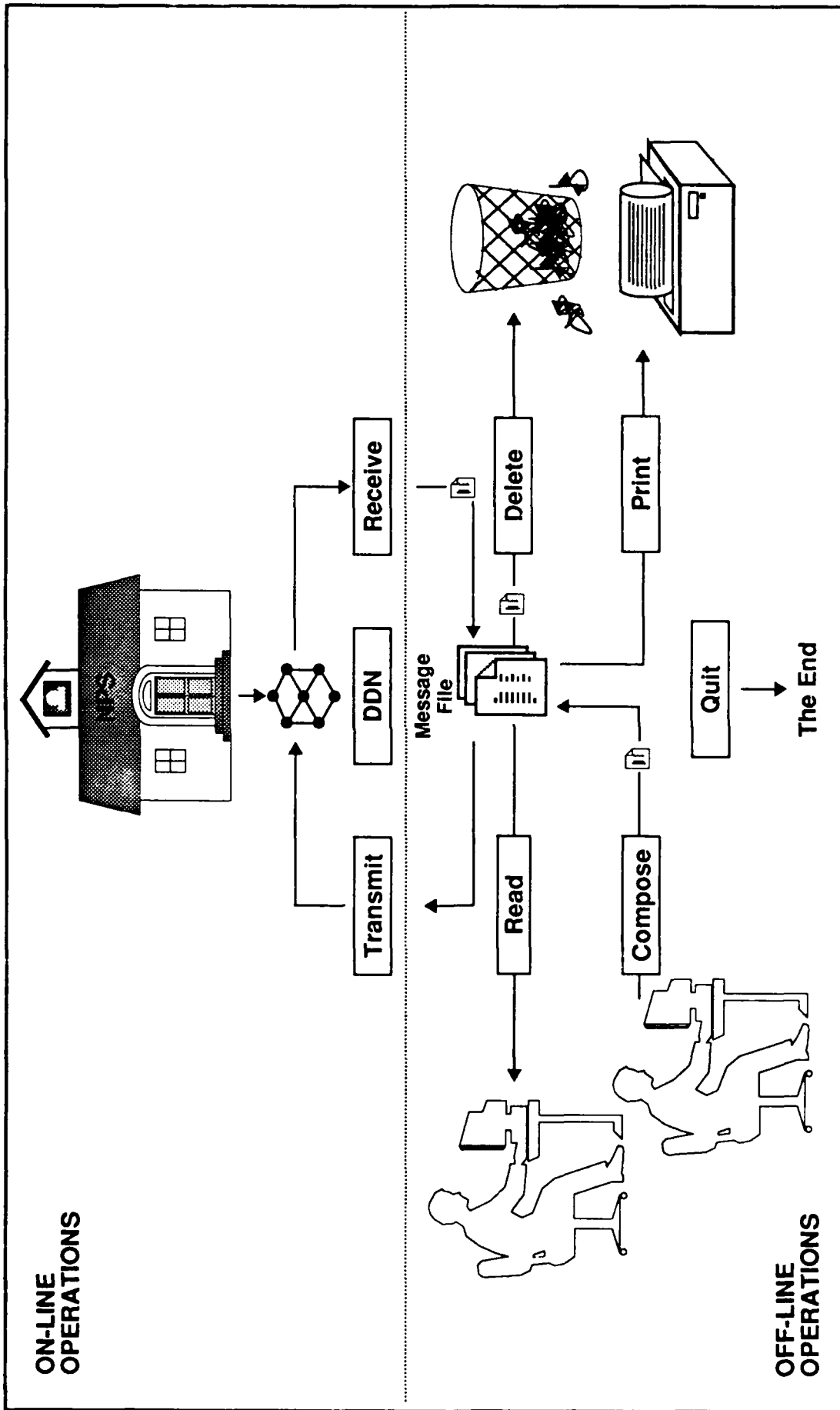
Figure 2. Organization of Instructional Support Network program.

ON-LINE
OPERATIONS

OFF-LINE
OPERATIONS

Receive

DDN

Transmit

Delete

Message
File

Read

Print

Compose

Quit

The End

store it in the Message File. DELETE allows the student to discard messages from the Message File. PRINT allows the student to print hard copies of messages. QUIT ends the program.

The program's main menu screen is shown in Figure 3. When an option is selected, a secondary screen is presented. All secondary screens look and behave similarly. There are no third-level screens, typed-in commands, or setup displays.

Instructional Support Network (ISN)

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Main Menu

| >> RECEIVE: Receive mail messages form your tutor at NPS. |

READ: Read mail messages received from your tutor at NPS.

COMPOSE: Compose mail messages to your tutor at NPS.

TRANSMIT: Send mail messages to your tutor at NPS.

DELETE: Select and delete mail messages.

PRINT: Select and print mail messages.

QUIT: Leave ISN program and return to DOS.

....

Use ↑ and ↓ to select menu option. Then press the ENTER key.

Figure 3. Instructional Support Network main menu screen for student software.

ISN User Documentation

A decision was made to provide users with the minimum amount of documentation necessary to assemble their systems, operate them, and resolve any possible problems (Simpson & Pugh, 1989). The guide consists of brief overview material ("Welcome," "About this Guide," "Preface") and four content chapters:

1. Getting Started--inventorying, assembling, and testing hardware.

2. How to Use the ISN Program--a tutorial on how to use the program.

3. ISN Communication Conventions--communication style, rules for communication, how to compose mathematical expressions.

4. Handling Problems--What to do when something doesn't work.

The guide is as short and simple as possible. Chapter 1, which tells how to assemble hardware, contains numerous illustrations; Figure 4 shows a typical page. Chapter 3 presents brief step-by-step instructions. Chapters 3 and 4 are short and organized like glossaries.

It was hoped that users would read the guide, but assumed that they might not. Consequently, users were provided with a "hot line" phone number to call in the event of problems and the software was written with extensive prompts and help messages to be internally "self-documenting."

Software Testing

Project personnel tested ISN software continually as it was being developed by the software contractor. This testing commenced when the first software modules were ready for use and continued throughout software development, a period of approximately six months. The tests were performed to identify and correct software bugs and to assure that the software met the design principles of simplicity, visibility, consistency, and self-documentation. Software tests were designed to exercise every probable user action as well as less probable but possible user actions. Testers attempted to misuse the software as well as to use it as intended; various errors were intentionally made in order to ensure that the system would not crash (the unbreakability principle).

After preliminary software testing, the ISN was installed by the contractor and used in a beta test environment by both the contractor and project personnel. The ISN was used for within-office communication for about two months before the field test began. The beta test allowed project personnel to evaluate the capability of the ISN to meet the needs of users. Beta testing uncovered several problems not evident during initial testing; e.g., the NPS mainframe purged messages at three-day intervals, resulting in lost messages. These problems were corrected before conducting the formative evaluation and field test.

ISN EVALUATION METHODOLOGY

Objectives

The ISN evaluation had three main objectives:

1. Determine how easy it was to learn to operate and use the ISN.

2. Document the support requirements and problems associated with installing and maintaining a system such as the ISN.

3. Determine the impact of the ISN upon student attrition, performance, and attitudes.

The context of the evaluation was a sequence of NPS Continuing Education (CE) calculus courses.

The first and second objectives focus on process and the third focuses on product.
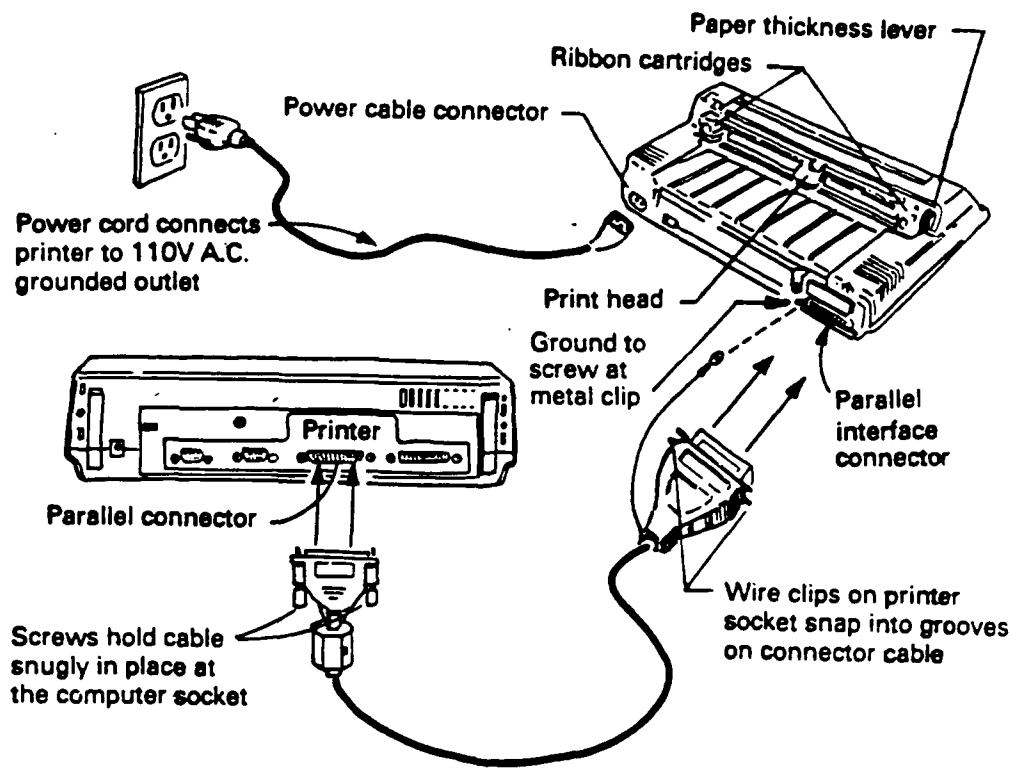
Figure 1-8. Connecting the printer cable.

7. Locate the grounding clip on the printer end of the cable.

8. Connect the grounding clip to the Phillips head screw above and to the left of the cable connecter on the back of the printer (see Figure 1-8).

9. Connect the power cord to the back of the printer.

10. Plug the power cord into a grounded outlet.

11. If a floppy disk is in the drive of your Z-184, remove the disk.

12. Turn on your Z-184.

13. Turn on your printer.

Figure 4. Typical page from *Instructional Support Network User's Guide*.

Formative Evaluation

A formative evaluation of the ISN was conducted to ensure that the aspects of the ISN that we could control--hardware, software, and documentation--were sufficiently refined for release to the ISN's intended users. Though we had made every effort to test and refine the ISN, we were sure that some of its shortcomings would only become evident once it was in the hands of actual users.

We solicited test subjects from NPRDC personnel by running a notice in the NPRDC weekly newsletter. The notice requested personnel with limited computer experience to act as test subjects. The incentive to participate was to gain some experience with the Z-184 computer. The five NPRDC volunteers had little or no computer experience.

Each subject was shown to a room and provided with a copy of the *ISN User's Guide,* a Phillips head screwdriver, and the cartons containing the ISN equipment. A researcher instructed each subject to follow the directions in the user's guide to unpack and set up the ISN, and to use it to send and receive a message. The researcher then left the room and waited for the subject to complete the task alone.

Process Measures

The following forms of process data (relating to evaluation objectives 1 and 2) were collected during the ISN field test:

Student message traffic. All student and tutor messages were sent both to the addressee and to a file accessible to researchers. These messages provided a historical record of all student-tutor communications. It was anticipated that the message traffic would eventually be analyzed to develop a number of descriptive measures relating to message-generation rate and message content (e.g., administrative, technical, motivational, etc.).

Support requirements. The ISN evaluation required the support of a tutor, software engineer, hot-line person, and programmer in the computer center at NPS. We recorded the amount of time these individuals spent per week supporting the ISN during the field test.

Tutor comments. Researchers and the tutor met before, during, and after the field trial. Notes were kept for all these meetings. A formal debrief interview was conducted with the tutor and his supervisor at the end of the field trial. In addition, the tutor provided written comments on strengths and weaknesses of the ISN and suggestions for improvements.

Contractor technical problem log. The software contractor recorded all problems encountered during software development and field testing. These problems were described in a technical report that the contractor submitted at the conclusion of the ISN software development (Newbury, 1989). Key information from this report is summarized in the Findings section of this report.

Formal Evaluation

The formal evaluation of the ISN focused on evaluation objective 3.

Research Design

A two-group design was used with an experimental group (participants in ISN) and control group (conventional instruction).

Subjects in the experimental group were provided with the ISN and received tutoring via the ISN from a tutor at the NPS; these subjects were not permitted to receive help from a local tutor. Subjects in the control group were not provided with the ISN and received tutoring in the conventional way from a local tutor whom they had to recruit. One of the shortcomings of the CE system is that students sometimes had difficulty finding a qualified tutor or were reluctant to make demands upon their tutor's time. As a consequence, some students either did not work with a tutor or did not take full advantage of the tutor's skills. It was anticipated that the ISN would overcome this limitation because a highly-qualified tutor would be available with minimum effort from the student. Based on this analysis, it seemed a reasonable hypothesis that the ISN would positively affect students in the experimental group.

Except for the manner in which tutoring was provided, all subjects received the same training and testing materials and followed the same procedures. Students were enrolled in NPS CE mathematics courses numbered MA1133 through MA 1140. This series of beginning calculus courses covers the same material as the first year of college calculus. Students in both groups were taking courses at various levels; i.e., not all students in both groups were taking exactly the same course. Course materials consisted of a student textbook, guidebook, and final examination.

Subjects

It was originally planned to use a total of 40 subjects, with 20 in each group. All subjects were participants in the NPS CE calculus course sequence. The majority of subjects were active duty military personnel with a rank equivalent to or lower than Navy lieutenant. Some DoD civilians also participated in the study. The NPS CE office provided researchers with a list of names and telephone numbers of personnel who had enrolled in one of the CE calculus courses. A researcher contacted each enrollee by telephone. Subjects were randomly assigned to a group (experimental or control) without regard to their educational background, mathematical ability, or other variables. Subjects who either expressed unwillingness to use the ISN or did not have convenient (i.e., toll free) access to a TAC for communicating over the MILNET were excluded from the experimental group. Two subjects refused to participate in the experimental group because they had a highly qualified local tutor.

All subjects in the experimental group were provided with Z-184 computers and ALPS printers and ISN software described in greater detail in the ISN Design and Development section of this report.

Data Collection

It was originally planned to use the methods and collect the data as described below:

17

Student Academic Profile Code. This composite score, computed by the NPS, reflects grade point average and level of achievement in engineering- and science-related courses. This measure was to be obtained from the NPS CE department.

Pre-course background interview. The questionnaire used during the pre-course telephone interviews of students contained questions concerning the student's computer background, willingness to participate as a test subject, and a ress to MILNET. It was used both to gather student background information and assign subjects to the experimental or control group.

Student final examination scores. These scores were to be obtained from the NPS CE department.

Student debrief interview. The questionnaire used during post-course telephone interviews of students contained questions concerning students experiences in and attitudes toward the course.

Research Variables

Subjects in the experimental group participated in the ISN and those in the control group received conventional tutoring. The independent variable is type of tutoring; i.e., ISN tutoring versus traditional tutoring.

Three dependent variables were chosen:

Attrition. Since NPS CE instruction has histo cally experienced a high attrition rate, attrition rate was an important measure of ISN effectiveness. The field trial period was limited to several months, allowing as few as four months for a particular student to participate; historically, students have sometimes taken up to a year to complete a course. Hence, we developed an operational definition of course completion for use for a shorter time window. We defined course completion as the percentage of students in either group (experimental or control) who had completed the course in eight weeks. The eight weeks were measured from the date the course materials were sent to the date the course final examination was received by NPS.

Performance. The score on the course's final exam represents student performance.

Attitudes. Several measures were obtained from students at the termination of the project regarding their attitudes toward the course, method of instruction, and quality of instruction.

The evaluation plan called for gathering data on control variables relating to student individual differences. Student scholastic ability was to be determined from student Academic Profile Code. Telephone interviews of students were planned to obtain data concerning student workload, schedule conflicts, interest in course material, career goals, and student mathematical ability. Students who participated in the ISN were also asked to report on various problems in using the ISN.

Changes to Formal Evaluation Methodology

The evaluation plan was written during the fall of 1988. When the ISN field test commenced in mid-February 1989, the NPS CE department began to provide NPRDC with the names of course

enrollees at the rate of about two per week. After about six weeks, the NPS CE department informed NPRDC that the CE program was under scrutiny by NPS management and was in danger of being terminated; no further names of students were provided. After several weeks of uncertainty, the CE program was terminated. NPS stated that it would support current enrollees in the program, but would not enroll new students. However, attrition in the small staff of the CE department and failure to replace the loss severely reduced the ability of the department to support students and provide us with data. Termination of the CE program had the following effects on the formal evaluation:

1. The number of students in the experimental group was reduced from 20 (planned) to 10 (the number recruited when the program was terminated). We obtained the names of 20 students for the control group. Consequently, the number of students was 10 ISN and 20 controls, for a total of 30.

2. The NPS was unable to provide student final examination scores; this precluded the use of this variable as a measure of student achievement.

3. The NPS was unable to provide student Academic Profile Codes; this precluded use of this variable as a measure of student scholastic ability.

The unanticipated developments in the CE program crippled the formal evaluation in two ways. First, the reduction in subject population size reduced the likelihood that statistically significant results could be obtained in comparisons between experimental and control groups. Second, the inability of the NPS to provide objective measures of test performance and academic background forced us to rely more on process-type measures obtained from questionnaires than on objective, product-type measures.

FINDINGS

Overview

This section describes the ISN evaluation in terms of the formative evaluation, process measures, and formal evaluation.

Formative Evaluation

All subjects were able to unpack their system, set it up, get it running, receive a message, print a message, compose a message, and send a message within less than two hours. During post-performance interviews, all subjects stated that they had found the directions in the user's guide easy to follow and the software easy to use. Subjects offered several suggestions for improving the guide; many of these suggestions were eventually incorporated in the revised version of the user's guide.

Process Measures

Student Message Traffic

All student and tutor messages were forwarded to a computer file at NPRDC for later analysis to determine message content and origin. The content of each message was classified as administrative (nontechnical, relating to course procedures, schedules, rules), technical (relating to course content), or motivational (tutor reminders, encouragements, and warnings about class participation). The origin of each message was classified as student or tutor. Table 1 summarizes the message content data for the 225 messages. The majority (72.9%) were administrative, 17.3 percent were technical, and 9.8 percent were motivational. Considering that the ISN was intended to be a tutoring system, the percentage of technical communication is surprisingly low. Three of the four students who completed the course (students 1, 5, and 10) sent almost no technical messages. Students 3 and 4 account for the majority of all technical communication but only student 3 completed the course.

Table 1

Message Content by Individual Student and Overall

Student	Message Origin			Total
	Administrative	Technical	Motivational	
1*	17	0	4	21
2	14	2	4	20
3*	13	14	1	28
4	25	13	2	40
5*	21	0	1	22
6	20	3	1	24
7	17	6	1	24
8	2	0	2	4
9	9	0	3	12
10*	26	1	3	30
Totals	164	39	22	225
Percent	72.9	17.3	9.8	100.0

*Students who finished the course.

Nontechnical messages may have been of motivational value by linking otherwise isolated students to someone interested in their success.

Table 2 summarizes the message origin data. Overall, students initiated 40.9 percent of all messages; the tutor generated the majority of messages. One might expect that more successful students would tend to initiate a higher percentage of their messages but the data do not support this idea.

Table 2

Message Origin by Individual Student and Overall

Student	Message Origin			Percent Student Generated
	Student	Tutor	Total	
1*	7	14	21	33.3
2	6	14	20	30.0
3*	13	15	28	46.4
4	23	17	40	57.5
5*	7	15	22	31.8
6	10	14	24	41.7
7	10	14	24	41.7
8	0	4	4	0.0
9	3	9	12	25.0
10*	13	17	30	43.4
Totals	92	133	225	40.9

*Students who finished the course.

ISN Support Requirements

The ISN required several kinds of support. Support personnel included a full-time tutor and a part-time software engineer who monitored the network to identify, diagnose, and correct technical problems and provided technical support. In addition, a researcher was available to provide hot-line support to students who were experiencing difficulties, and personnel in the NPS computing center provided occasional support to the ISN. The amount of support was greater when the system was being set up than after its operation had reached a steady state and it was running smoothly. After that point was reached, the technical support by the software engineer averaged 1 or 2 hours per week. hot-line support about 30 minutes per week, and computer center support about 30 minutes per week. The tutor estimated that he could have tutored 40 students with the ISN (and perhaps more), since he was able to tutor 10 students in less than 10 hours per week.

Tutor Comments

During the final month of the field test, two project researchers conducted an open-ended interview of the NPS tutor. They asked a series of questions concerning the tutor's perceptions of ISN strengths and weaknesses and suggestions for improvements. In addition, they asked the tutor for written comments on the ISN. The written and oral comments, which followed closely, are summarized below:.

The tutor stated that the ISN was a "great" tutoring tool. It was easy to learn to operate and use, and both students and tutor could operate it effectively in a short time.

The tutor identified several problems during the field test:

1. **Slow student progress with lessons.** This is not a problem with the ISN, but with student performance in CE programs generally. The tutor believed that most students tended to progress slowly because of conflicts with their work duties, home life, or other interests.

2. **Lack of communication by students.** The ISN "contract" (the terms under which students were lent their computer) required that each student communicate at least once per week. Most did not communicate this often or communicated in a very cursory fashion.

3. **NPS host computer problems that precluded student-tutor communication.** At various times, the IBM host computer rejected or lost ISN messages and the communicators could not tell that their messages were not getting through. This problem was caused by unanticipated side effects of IBM software modifications and was only detected after long periods of noncommunication.

4. **DDN problems that precluded student-tutor communication.** The DDN, at various times, disrupted communication. The primary cause was unreliable TAC phone lines that would reject telephone communications.

5. **Inability (by tutor) to diagnose cause of student noncommunication.** There was no easy way to tell if student disinterest, difficulty operating the ISN computer or software, host computer problems, or DDN problems caused the lack of communication.

The tutor made several suggestions for improving the ISN:

1. Provide students with a syllabus containing a suggested schedule for progress through their course.

2. Work with students' work supervisors to allow them to "ease off" on their duties to provide more time for their studies.

3. Improve the ISN software by providing additional capabilities such as improved graphics capabilities, a hypertext-style subject matter database, and improved text editor.

The tutor worked under the supervision of a senior mathematics professor who oversaw ISN tutoring at NPS but did not tutor students with the ISN. The supervising professor had developed

content for several CE mathematics courses and had several years of experience with the CE program. Though he was not directly involved in ISN tutoring, his experience enabled him to put the ISN into the context of conventional tutoring and to make a comparison between the two. The professor was interviewed shortly after the tutor, using the same protocol. The professor remarked that the biggest problem with CE courses was to get students to complete them According to the professor, the school had no system to follow up on students, but the ISN provided at least a partial answer to this problem. He remarked, "My impression is that ISN has very good effects on students staying in the program." He added that the system of instruction used in CE courses was based on students working with tutors who possessed subject matter knowledge but that many students were unable to find suitable tutors; the ISN compensated for this shortcoming.

Technical Problems

This section summarizes the technical problems that NPRDC and its software development contractor encountered with the ISN while it was in use, described in detail in Newbury (1989).

The ISN is a complex arrangement of computers, software, and long-distance networks. System operability depends on all components working properly; the failure of any single component usually compromises the entire system. While the ISN was in use, nearly every component in it failed at least once. Most failures were minor and were quickly corrected, but a few affected the ISN for several weeks and required software modifications.

Table 3 summarizes the types of failures that occurred while the system was in use. Not all the documented problems were reported by the students. Some reported problems were noticed by the researchers at NPRDC and were corrected before they affected the operation of the student systems.

Table 3

Summary of Technical Problems
(from Newbury, 1989)

System Component	Number of Failures
Laptop Hardware	2
Custom Laptop Software	3
Commercial Laptop Software	0
Improper Laptop Configuration	2
NPS IBM Hardware	8
NPS IBM Software	8
MILNET Hardware	6
TAC Hardware	5
Telephone Lines	1
Total	35

Laptop hardware failures. Failures of the Z-184 computers were rare and were usually corrected by replacing the broken equipment. In one case the power supply for the computer failed. In another case, there were undiagnosed problems with the computer and it was replaced. The biggest problem with hardware failures was that the equipment had to be packed and sent to San Diego, and new equipment had to be shipped to the student. While this was happening, the student could not use the system.

Custom laptop software failures. Early versions of the custom laptop software contained some bugs that were found by NPRDC and its software development contractor shortly after the ISN became operational. Two of the configuration programs contained bugs that caused data to be lost and another bug in the software caused it to crash; however, these problems were corrected before the software was shipped to students.

Commercial laptop software problems. Some problems were encountered with the CSE text editor and the Procomm communications software during ISN development. Our programmers lacked the source code for these packages and could not modify the underlying programs. Consequently they had to find ways to work around certain program deficiencies. For example, they improvised ways to disable the keyboard while Procomm was running (which would break communication) and to prevent users from typing past the 80th column when using the text editor (which would shift the display laterally). Both commercial software packages were very reliable and there were no reported failures of either one.

Improper laptop configuration. In two cases, the laptop software was improperly configured before systems were shipped to students. In both cases, the problem was identified with a hot line telephone conversation and NPRDC personnel provided the users with instructions for correcting their problem.

NPS IBM hardware failures. Host IBM hardware failures include both hardware failures, which were infrequent, and when the host was down for planned maintenance or due to operating system crashes. These failures occurred often enough that students could not transmit or receive messages when they wanted. If a student attempted to send or receive a message when the host was down, ISN software sent a message instructing the student to transmit the message later.

All multiuser systems require some down time for maintenance and to handle the occasional hardware and software crashes. The staff at NPS reported that their system operates 99 percent of the time. However, at least five times during June 1989, the host computer was not running during normal working hours. While the host IBM computer appeared to be down more often than other computer systems, it was not possible to determine if the down time was excessive.

NPS IBM software failures. Host IBM software failures consisted of VM/CMS operating system failures and MILNET software failures.

VM/CMS operating system problems caused two failures. The first was caused by a shortage of disk space on the host, which the NPS computer center staff dealt with by deleting all messages more than three days old. Since students did not necessarily read their messages every three days, this resulted in the unfortunate loss of many unread messages. When the oversight was realized,

NPS staff exempted student accounts from the automatic message deletion requirement. The second failure occurred when the host computer's software started returning all messages to the sender. The problem lasted several days, and was eventually corrected by the NPS staff.

Failures in the MILNET networking software on the host computer resulted in several communication interruptions. The VM/CMS operating system does not provide strong support of MIL-NET communications and the problems experienced are common to the family of computers running this operating system. Eventually all of these problems were corrected, but, while present, they had serious effects. For several weeks, NPRDC researchers were unable to connect to the host computer at NPS through the MILNET because of networking software problems on the host. A more serious problem involved the routing of message copies from the host to the message archive on the NPRDC VAX computer. NPS computer center personnel discovered a problem in their MIL-NET software and changed the software to route all outgoing messages through the BITNET network to a computer on the east coast, where the messages were transferred to the MILNET for final delivery. NPS made this software change without notifying us and the ISN began to experience several problems until we were able to modify our software to deal with the new routing requirements.

MILNET hardware failures. All reported failures of the MILNET hardware were traced to a failure of MILNET hardware in San Diego. These problems affected only students in the San Diego area. Identifying and tracing the source of the problem required the help of the computer support staffs at NPRDC, NPS, and the DDN Network Information Center. This was costly and time consuming, and made apparent the requirement that systems such as the ISN have for support from high-level technical personnel.

TAC hardware failures. We are aware of five times when students could not connect to a TAC, but this problem occurred undoubtedly many times without being brought to our attention. TAC failures lasted from a few hours to several days. If the problem was reported to NPRDC and did not correct itself in a day or so, the affected students were given the telephone number of a different TAC and told how to reconfigure their laptop computer to use the new telephone number. Though the causes for all the TAC failures were not determined, the following types of TAC failures were common:

1. All telephone lines into the TAC in use, resulting in a busy signal.

2. Using a new TAC telephone number.

3. TAC power outage.

4. TAC hardware broken or undergoing maintenance.

5. TAC temporarily or permanently disconnected.

Telephone line failures. The only recorded telephone system problem was due to an internal telephone system rather than the external telephone company lines. This problem resulted from incompatibility between the ISN software's requirements for touch-tone dialing capability and a

phone system using newer digital dialing with special signals. The student was unable to use the ISN in this phone system but was able to use it elsewhere.

Student Attrition

Students were asked during the post-course debrief interview how much course work they had completed. Their responses were used to place them into one of two categories:

Category A. Student had taken (or attempted to take) the course's final exam within eight weeks of enrollment. An attempt to take the final exam was counted as success because the NPS CE program, during its twilight, did not always keep up with student requests for tests and, historically, virtually all students who took exams passed them with a grade of "B" or higher.

Category B. Student did not meet the criteria of Category A.

These two categories provide a way of classifying students in terms of attrition. Category A students were classed as nonattrites and Category B students as attrites.

Table 4 shows the number of students in each category by group. The control group contains a greater proportion of attrites than the ISN group. Table 4 suggests that the ISN reduced attrition, but this conclusion requires statistical verification. The small number of subjects precluded the use of statistical measures based on simplifying assumptions about underlying population distributions. Thus, Fisher's exact test (Bradley, 1968) was used on the data in Table 4 to calculate the probability directly. The result (the probability that the null hypothesis is true) is not statistically significant.

Table 4

Number of Nonattrites and Attrites by Experimental Group

Exp. Group	Nonattrites	Attrites	Totals
ISN	4	6	10
Control	5	15	20
Totals	9	21	30

Student mathematics background might also affect attrition. More than half of all NPS CE calculus students had previously taken calculus and enrolled in a CE course for review. It is a reasonable hypothesis that, the stronger the mathematics background, the less likely the student would be to drop out of the class.

Table 5 shows the number of students in each mathematics background category by group. The "low" group had three or less semesters of calculus; the "high" group had four or more semesters of calculus. These data indicate that the control group had about twice as many students with high mathematics background as did the ISN group.

Table 5

**Number of Students in Each Mathematics
Background Category by Experimental Group**

Exp. Group	Math. Background		Totals
	Low	High	
ISN	8	2	10
Control	13	7	20
Totals	21	9	30

To test this hypothesis, a one-way between-groups analysis of variance was calculated to determine the impact of mathematics background on attrition. The result ($F(1,28) = 2.35$, $p = .14$) is not statistically significant, but suggests (as does common sense) that this variable plays a role in attrition.

Figure 5 shows the mathematics background of nonattrites and attrites by experimental group. The mathematics background of nonattrites is slightly higher in the control than in the ISN group. A much greater difference exists for the attrites; attrites in the control group have had almost twice as much mathematics as those in the ISN group. This leads one to wonder if the ISN is particularly beneficial to students with a weak mathematics background. Our data suggest that ISN students with weaker mathematics background were less likely to attrite than were controls.

Table 6 shows the number of students with low mathematics background in terms of attrition category and group. The data in Table 6 enabled us to test the hypothesis that the ISN is particularly helpful to students with weaker mathematics backgrounds. Fisher's exact test was used to compute the probability that the null hypothesis is true for the data shown in Table 6. The computed probability is not statistically significant.
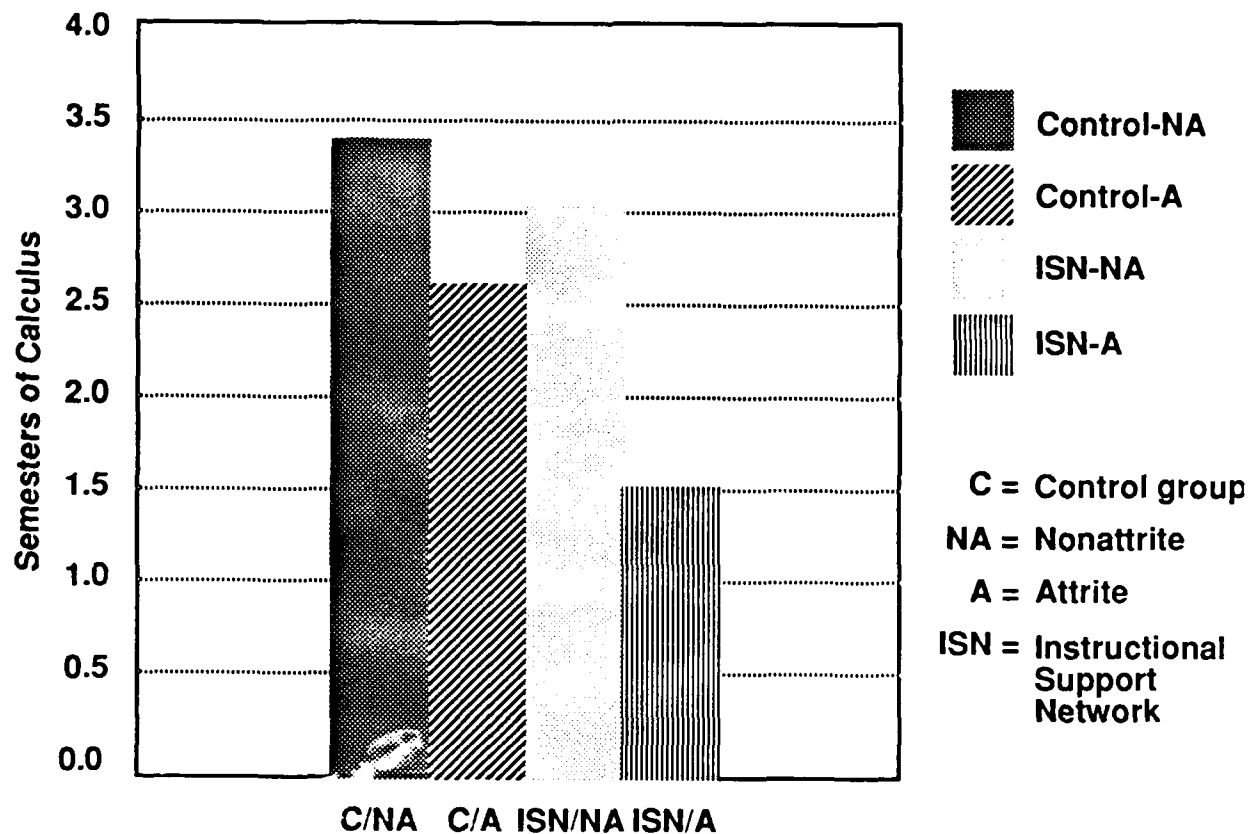
Figure 5. Mathematics background of students by group and attrition category.

Table 6

Number of Students with Low Mathematics
Background by Attrition Category and
Experimental Group

Exp. Group	Nonattrites	Attrites	Totals
ISN	3	5	8
Control	1	12	13
Totals	4	17	21

Student Attitudes

During the student debrief interview, students were asked to rate various dimensions of the class they had taken and the tutor they had worked with. These ratings are summarized in Tables 7 (Course) and 8 (Tutor) for each dimension rated by attrition group.

28

Table 7 shows student ratings of class utility, overall quality, and perceived difficulty on a rating scale from 1 (low) to 5 (high). Overall, the ISN group tended to rate the class more favorably than did the control group. Students in the ISN group rated class usefulness and quality higher, and class difficulty lower, than did controls. None of the between-groups analyses of variance for these comparisons was statistically significant.

Table 7

Student Ratings of Class Usefulness, Quality, and Difficulty by Experimental Group and Attrition Category

Class Dimension	ISN				Control		
	A	B	A&B		A	B	A&B
Usefulness	4.0	4.6	4.3		4.4	3.6	3.8
Quality	4.5	3.6	4.0		3.6	3.6	3.6
Difficulty	3.5	3.2	3.3		3.0	3.7	3.5

Notes.
1. Group A = Nonattrites, Group B = Attrites.
2. Rating scale ranges from 1 = low to 5 = high.

Table 8 shows student ratings of tutor responsiveness, knowledge of mathematics, tutoring skill, and an overall rating using the same rating scale (from 1 = low to 5 = high). The ISN group tended to rate all dimensions more favorably than did the control group. Between-groups analyses of variance indicated statistically significant differences on the knowledge of mathematics and tutoring skill dimensions.

Though the differences between groups on most of these ratings are quite small, they tend to indicate that students in the ISN group were more favorably disposed toward their learning experience than were those in the control group.

The most important finding of the evaluation is that it is possible to design and develop a system that is economical, rugged, and easy to assemble; has simple and foolproof documentation; and can be operated by users with limited computer skills and technical support. Most systems that do what the ISN can do require users with considerable computer sophistication and are daunting for others. A system like the ISN--with its simple user interface, high degree of automation, and limited set of features--could make the powerful tool of electronic networking available to people who lack computer sophistication or who, usually for technical reasons, choose not to bother mastering more complex messaging systems.

Table 8

Student Ratings of Tutor Responsiveness, Mathematics Knowledge, Tutoring Skill, and Overall Rating by Experimental Group and Attrition Category

| Class | ISN | | | Control | | | A&B |
Dimension	A	B	A&B	A	B	A&B	Diff.
Responsiveness	5.0	4.2	4.6	4.5	4.0	4.1	0.5
Math Knowledge	4.8	5.0	4.9	5.0	4.1	4.2	0.7*
Tutoring Skill	4.8	4.3	4.5	4.0	3.5	3.5	1.0*
Overall	4.3	4.3	4.3	4.0	3.8	3.9	0.4

Notes.
1. Group A = Nonattrites, Group B = Attrites.
2. Rating scale ranges from 1 = low to 5 = high.

*$p < .05$.

It came as no surprise that the ISN required technical support, although the actual amount was low. The tutor was the most time-intensive user of the ISN, and, if the number of students were increased, the tutor's workload would increase. However, if the ISN were simply used for communication between individuals, it could operate with relatively little technical support.

It would have been informative if the attrition and attitude data had indicated the utility of the ISN for instructional purposes, for this would have demonstrated the ISN's usefulness in a practical context; i.e., with college-educated users who were working independently on a fairly difficult self-paced course with a dismal historical completion rate.However, the inconclusiveness of the data does not diminish the success of users in actually using the system.

Hypothetical ISN Upgrade

The ISN track of the Communication Networks in Training project was terminated after the ISN field test. During the early part of the field test, we became aware of several limitations of the ISN and began sketching the changes to be made to a second-generation ISN. This work was carried as far as developing a working prototype of the ISN-II's user interface and a statement of work for a contractor to actually develop the system. The system was not developed but its design would overcome some shortcomings of the prototype ISN.

The upgrade specifications call for improvements in the user interface, file handling capabilities, text editor, and message handling features, but its two most significant changes are the use of a local UNIX-based host computer and the addition of teleconferencing capabilities. Many of the ISN's problems resulted from the use of a host computer over which we had limited control and whose operating system and mail handler were crude compared to those available in the UNIX environment. Use of a local UNIX host would give a greater degree of control and improved message

handling. The prototype ISN permitted one-on-one communication between a single student and a single tutor. ISN-II would enable any user to address any message to any single user or combination of users; this capability would enable users (students or other types of users) to confer with their peers. This feature would also make the ISN useful for a great deal more than tutoring; e.g., for teleconferencing in a Navy conferencing network.

Navy Conferencing Network

The Navy does not have a conferencing network intended for general use. Since various Navy organizations, groups, and entities use the DDN to communicate, it can be argued that there is no need to change the status quo. Certainly no change is needed if the intended users can make effective use of existing communication resources. However, substantial evidence suggests that current electronic mail systems are not used or are misused because of their complexity. Simple messaging systems such as the ISN enable users to do perhaps 90 percent of what typical e-mail users need to do with perhaps 10 percent of the effort. Existing computer conferencing systems (e.g., the Army Forum Network) generally have primitive user interfaces and are difficult for computer novices and occasional users to operate. Because of such problems, our ISN work focused on very simple and easy-to-use terminal software whose design might serve as a model in the present application. The basic design problem was to make the software so simple and user-friendly that it could work with minimum outside support. It seems to have succeeded in meeting its usability objective. As such, it would be a good model for a Navy Conferencing Network aimed at a wider audience than is currently using the DDN with existing software.

CONCLUSIONS

The use of electronic mail appears to have limited application for instructional delivery in the Navy. However, an electronic mail system with the simplicity and user friendliness of the ISN would be a major improvement over existing electronic mail systems and would be useful for sharing information among training professionals and other Navy personnel.

RECOMMENDATIONS

1. Electronic mail should not be considered as a primary instructional delivery medium by the Navy.

2. The Chief of Naval Education and Training should give serious consideration to developing a Navy-wide, DDN-based, electronic-mail network for sharing information ("knowledge networking") among training professionals and other Navy personnel. The design of this network could be modeled on the ISN.

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APPENDIX

THE DEFENSE DATA NETWORK

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The Defense Data Network (DDN) is a large military data communications network operated for the Department of Defense by the DDN Program Management Office (DDN PMO) of the Defense Communications Agency (DCA). The DDN was developed in 1969 by the Defense Advanced Research Projects Agency (DARPA) as a research network, and later was used for operational military purposes.

The DDN links military and research computers throughout the United States and overseas. The DDN was designed to connect computers produced by different manufacturers and running different operating systems to the network. This is done by requiring that all computers connected to the network use a common communications protocol, called Transmission Control Protocol/ Internet Protocol (TCP/IP). All computers connected to the DDN are required to provide several network services. These include the ability to log onto other computers in the network (TELNET services), the ability to transfer files between computers (FTP services), and electronic mail services.

The DDN includes two major networks: ARPANET and MILNET. Both are unclassified military networks, but they have different uses. The ARPANET supports military research and development, including research on the ARPANET itself, and the MILNET is an operational network that supports normal day-to-day military data communications.

Users of the DDN have two ways to access the network. They can access the network through a host computer connected to the DDN. In general, all users who have password access on a DDN host computer also have automatic access to the DDN. Users also can access the DDN through a Terminal Access Controller (TAC). A TAC is a general-purpose connection to the DDN that can be used with a variety of terminals and computers. Scores of TACs are located throughout the United States. To use a TAC, users must have either a terminal connected directly to a TAC or a terminal and a modem through which they can dial a TAC. By entering a specific logon sequence, they can gain access to the TAC and, through the TAC, access computers connected to the DDN. Use of TACs is restricted to persons with a valid TAC Access Card. Temporary and permanent TAC Access Cards are obtained from the host administrator for a user's host computer.

DDN is logically part of the INTERNET, a collection of unaffiliated networks such as the NSFNET and the Supercomputer Network CSNET. These various networks are officially or unofficially gatewayed together at well-connected host computers around the United States. Today, more than 100,000 host computers are connected to the INTERNET.

Users of the DDN and TACs must be engaged in U.S. government business or applicable research or directly involved in providing operations or systems support for government-owned or government-sponsored computer communications equipment. The network is not available for use by the general public.

The DDN PMO has responsibility for overall management, operations, and policy guidelines for both the ARPANET and the MILNET. The DDN PMO provides many services, including keeping the network running, providing user assistance, anticipating growth and expansion, and maintaining network security. The DDN PMO has authorized the DDN Network Information

Center (NIC) to provide network services for the DDN, and the NIC is usually the first point of contact for users experiencing problems with the DDN. The NIC is located at SRI International in Menlo Park, California. The NIC maintains a host computer system containing documents and information about the DDN.

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